

Application of Functionalized SiO₂ in PEO Based Polymer Electrolytes

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Introduction

Among polymers that are able to solvate lithium salts [1], the polyethylene oxide (PEO) system is the most comprehensively studied. Practical applications of this class of polymer electrolytes are, however, limited by their low ionic conductivities at ambient temperature ($\sigma \leq 10^{-7}$ S cm⁻¹ at 25°C) and poor mechanical properties. One of the most promising ways to improve these properties is through the addition of ceramic fillers. Both the particle size and the chemical nature of the ceramic fillers are important considerations [2]. In this work, SiO₂ is functionalized to increase the efficacy of the polymer-ceramic interactions in the PEO/LiBF₄ system.

Experimental

Nanometer-size SiO₂ powder from Aldrich was functionalized by 2-[Methoxy(polyethylenoxy)-propyl] trimethoxy silane (Gelest), and characterized by XPS and TGA measurements. Polymer composite electrolytes with either pristine or functionalized SiO₂ were prepared by conventional film casting techniques. The stability of the polymer electrolyte/lithium metal interface was evaluated by monitoring the temporal changes in the impedance of symmetric Li/composite electrolyte/Li test cells under open-circuit conditions.

Results and discussion

The XPS spectra of Figure 1 confirm the successful completion of functionalization. The bands centering on binding energies of 283.2 eV and 284.8 eV are characteristics of CH₂ species and C-O-C groups respectively [3]. The latter arise from the functionalization reaction.

Figure 2 shows the TGA responses from both pristine and functionalized SiO₂. As temperature increases, the OH- groups on the SiO₂ surface begins to decompose, leading to some small weight losses. For pristine SiO₂ in Figure 2(a), the weight loss is 1.6% up to temperatures as high as 450°C. In Figure 2(b) for functionalized SiO₂, the weight loss occurs sooner at 350°C due to the decomposition of molecular chains of 2-[Methoxy(polyethylenoxy)-propyl] trimethoxy silane that are bonded to the SiO₂ surface.

From the evolution of interfacial resistance in Figure 3, SiO₂ after functionalization has improved the interfacial stability. This is attributed to the better affinity between SiO₂ powders and the PEO molecular chains after functionalization, thereby hindering the corrosion reaction between lithium and the electrolyte. Hence a better dispersion of SiO₂ powders is desirable for stabilizing the interface.

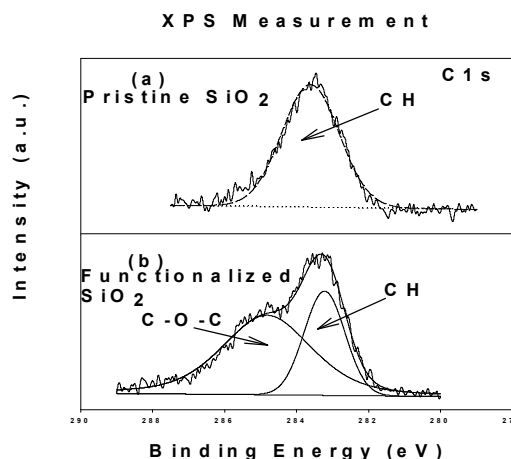


Figure 1 XPS measurements

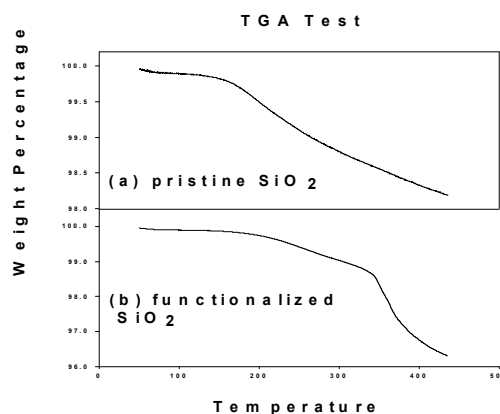


Figure 2 TGA measurements

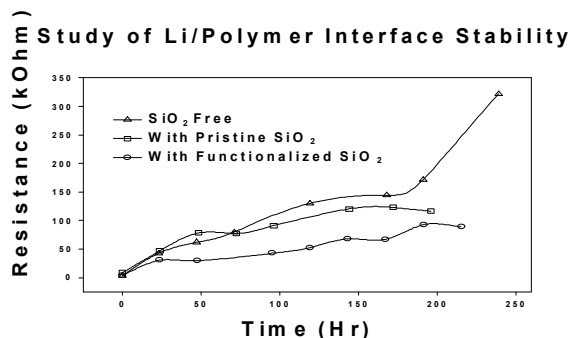


Figure 3 Stability of the Li/composite electrolyte interface

References

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